**Digestion: Summary of Nutrients & Digestion of Nutrients**

Summary of macronutrients:

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|  | Carbohydrates | Proteins | Lipids |
| Chemical structure: | -monosaccharides (single sugars), e.g., glucose, fructose  -disaccharides (double sugars), e.g., sucrose, maltose, lactose  -polysaccharides (long chain sugars), e.g., starch, cellulose (plant fibres) | -long chains of amino acids that are highly variable in length and shape  -20 amino acids in total, 8 are essential (i.e. cannot be produced by the body & must be consumed in food) | -fats & oils are **triglycerides** (made of glycerol + 3 fatty acid chains)  -fatty acids can be saturated (usually solid at room temperature, e.g., meat fats, butter) or unsaturated (usually liquid at room temperature (e.g., vegetable oils)  -essential fatty acids are unsaturated & cannot be produced by the body (e.g., omega-3 fatty acids) |
| What does the body use them for? | -main source of energy | -key building blocks of cell structures  -perform a wide range of functions  -form some hormones  -used to generate motion, etc. | -energy storage  -form cell membranes  -insulate organs  -form some hormones |
| How much? | -recommended to provide at least 55% of calories  -are stored in liver & muscles as glycogen; excess sugars are stored as fat | -recommended 10-30% of calories from protein | -recommended no more than 30% of calories come from lipids  -excess consumption can lead to heart disease & obesity  -"good" & "bad" cholesterol  -trans fats are hydrogenated unsaturated fats, but behave like saturated fats & raise bad cholesterol levels |

(Other nutrients include water, vitamins, minerals.)

How does your body physically & chemically digest these nutrients?

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|  | Carbohydrates | Proteins | | | Lipids |
| mouth | -physical digestion of all food types by teeth  -saliva dissolves food so that it can be tasted  -mucus lubricates food & aids swallowing of **bolus** | | | | |
| -salivary **amylase** starts to digest starch into disaccharides (chemical digestion) | |  |  | |
| stomach | -when food enters the stomach, *submucosa* cells release hormone **gastrin**  -gastrin stimulates *mucosa* cells to release gastric juice (mucus, hydrocholoric acid, digestive enzymes such  as pepsinogen)  -acid (pH around 2.5) kills harmful bacteria  -nerves signal muscular layer of stomach, *muscularis,* to contract, churning & mixing the food with the gastric  juices, turning it into **chyme** | | | | |
| -salivary amylase is deactivated by  low pH | | -HCl converts **pepsinogen** to its active form (**pepsin**)  -pepsin starts breaking down proteins into amino acids |  | |
| small intestines (mostly the duodenum) | -pyloric sphincter periodically relaxes, letting small amounts of chyme to enter the duodenum  -chyme causes release of hormone cholecystokinin (CCK) by *mucosa* cells in duodenum  -CCK stimulates pancreas to release various enzymes through the pancreatic duct into the duodenum  -CCK signals to the stomach to slow down digestion  -acidic chyme causes conversion of prosecretin in epithelial cells to **secretin**, which:  -stimulates liver to make more bile  -stimulates pancreas to release enzymes & bicarbonate ions (HCO3-), which raise the pH to 9.0  -signals stomach to slow down release of chyme into duodenum  -presence of lipids in chyme causes gall bladder to contract, releasing bile through the bile duct into the  duodenum | | | | |
| -pancreatic amylase continues breakdown of starch into di- and monosaccharides | | -pepsin is inactivated by pH 9.0  -trypsinogen (from the pancreas) is converted to **trypsin** by enzyme **enterokinase**; trypsin further breaks down proteins  -carboxypeptidase & erepsins break down short proteins into individual amino acids | -**bile** emulsifies fat into smaller droplets (physical digestion)  -lipases (from the pancreas) break lipid chains into shorter chains & individual fatty acid molecules | |